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Advantages of metaheuristics for multi-dataset calibration of hydrological models

Silja Stefnisdóttir[1,2], Anna E. Sikorska-Senoner[3], Eyjólfur I. Ásgeirsson[1,2], and David C. Finger[1,2]
[1]Reykjavik University, Reykjavík, Iceland
[2]Sustainability Institute and Forum (SIF), Reykjavik University, Reykjavik, Iceland
[3]Department of Geography, University of Zurich, Zürich, Switzerland

Hydrological models are crucial components in water and environmental resource management to provide simulations on streamflow, snow cover, and glacier mass balances. Effective model calibration is however challenging, especially if a multi-objective or multi-dataset calibration is necessary to generate realistic simulations of all flow components under consideration.

In this study, we explore the value of metaheuristics for multi-dataset calibration to simulate streamflow, snow cover and glacier mass balances using the HBV model in the glaciated catchment of the Rhonegletscher in Switzerland. We evaluate the performance of three metaheuristic calibration methods, i.e. Monte Carlo (MC), Simulated Annealing (SA) and Genetic Algorithms (GA), in regard to these three datasets. For all three methods, we compare the model performance using 100 best and 10 best optimized parameter sets.

Our results demonstrate that all three metaheuristic methods can generate realistic simulations of the snow cover, the glacier mass balance and the streamflow. The comparison of these three methods reveals that GA provides the most accurate simulations (with lowest confidence intervals) for all three datasets, for both 100 and 10 best simulations. However, when using all 100 simulations, GA yields also some worst solutions which are eliminated if only 10 best solutions are considered.

Based on our results we conclude that GA-based multi-dataset calibration provides more accurate and more precise simulation than MC or SA. This conclusion is fortified by a reduction of the parameter equifinality and an improvement of the Pareto frontier for GA in comparison to both other metaheuristic methods. This method should therefore lead to more reproducible and consistent hydrological simulations.